# AMS-02 Integration Hardware Fracture

## AMS-02 CDR
## Integration Hardware
## Fracture Analysis

# AMS-02 Integration Hardware Fracture

- **Fracture Control**
  - **Establish fracture control requirements of the AMS-02 payload integration hardware for Space Shuttle and International Space Station (ISS)**
  - **Examine the flight hardware for identification of fracture critical components and implement appropriate inspections, analysis and controls**
  - **Ensure safety of crew, Orbiter and ISS such that failure of any structure will not result in a catastrophic hazard**

# AMS-02 Integration Hardware Fracture

- **Fracture Control (cont)**
  - **Reference documents:**
    - **Fracture Control Plan for JSC Flight Hardware (JSC 25863, Rev. A), August, 1998**
    - **Fracture Control Requirements for payloads using the Space Shuttle (NASA-STD-5003), October, 1996**
    - **Fracture Control Requirements for Space station (SSP 30558, Rev. B, June 1994)**
    - **Fatigue crack Growth Computer program NASGRO version 4.02, September 2002**

# AMS-02 Integration Hardware Fracture

- **Fracture Control (cont)**
  - **Design Safe-life verification for AMS-02**
  - **Combined fatigue loading spectrum derived in LMSEAT 33818, Rev. A, February 2002.**
  - **Spectrum includes Air transport, Truck transport, Launch/Landing and on-orbit loading events**
  - **STA vacuum case includes sine sweep test and acoustic test spectrums**
  - **3 Orbiter missions for Lift-off/Landing**
  - **3 operational years and 2 contingency years duration on ISS**
  - **Scatter factor of 4 is used for the analysis**

# AMS-02 Integration Hardware Fracture

- **Fracture Control (cont)**
- **Classification of AMS-02 integration Hardware Components**
- **Non-Fracture Critical Parts**
  - **Low released Mass (<0.25 lb)**
  - **Contained**
  - **Fail-safe**
  - **Low risk**

# AMS-02 Integration Hardware Fracture

- **Fracture Control (cont)**
- **Pressurized Components/Sealed containers**
  - **Non-Hazardous Leak-Before-Burst (LBB) mode of failure**
  - **Through the thickness crack with length 10 times wall thickness will not result in unstable fracture**
  - **Components, lines and fittings comply with NSTS 1700.7B and ISS addendum**
  - **Components are made from metal alloys**
  - **Components that sustain continued crack growth should have safe-life against burst for remaining cycles**

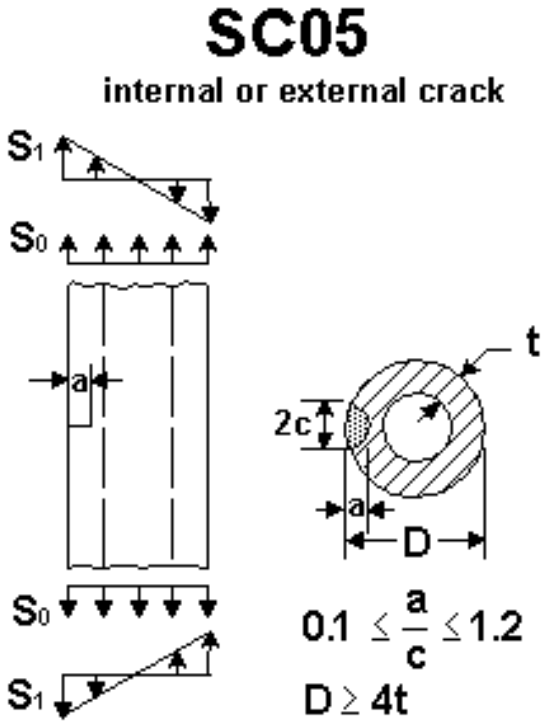
# AMS-02 Integration Hardware Fracture

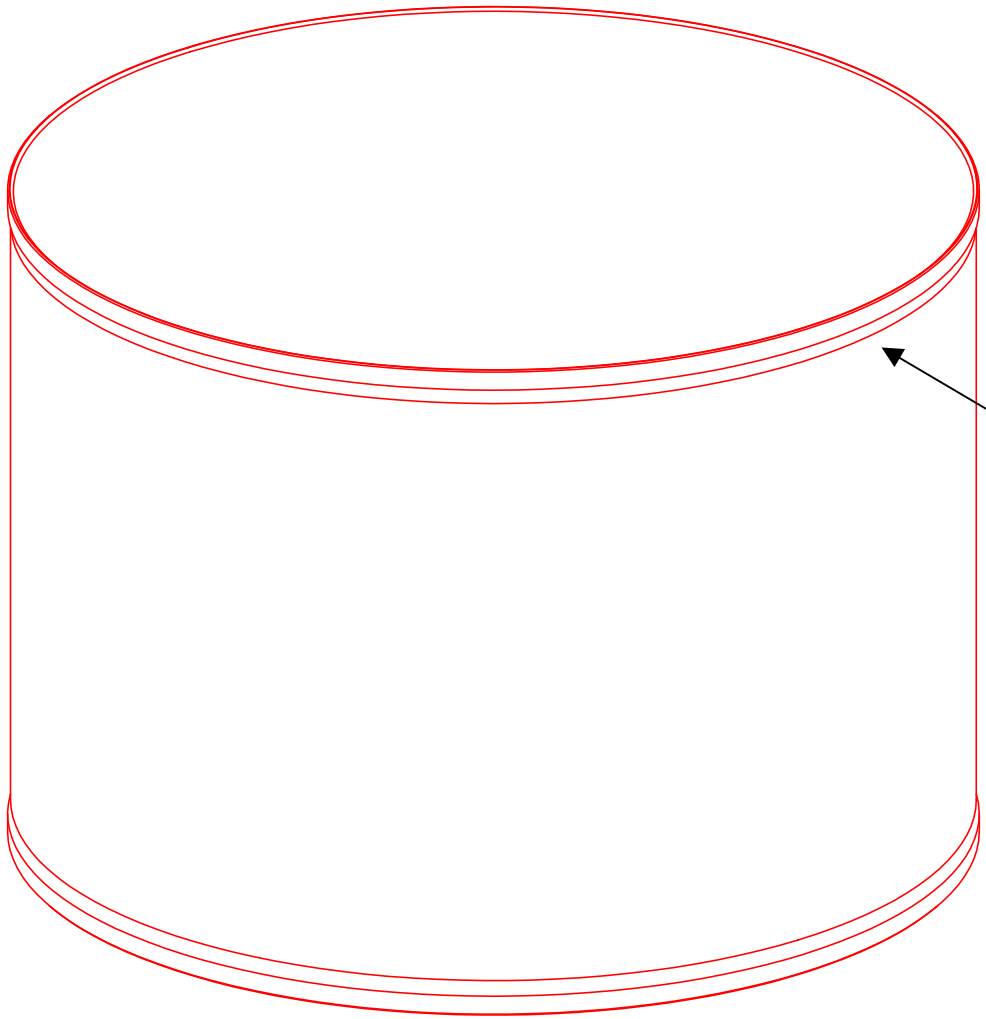
- **Fracture Control (cont)**
- **Fasteners and shear pins**
  - **To be classified as fail-safe parts they must meet the following requirements:**
    - **Shown by analysis or test that due to a single failure the remaining structure can withstand the loads with a factor of safety of 1.0**
    - **Adequate quality control is implemented to ensure that the remaining structure is unflawed**

# AMS-02 Integration Hardware Fracture

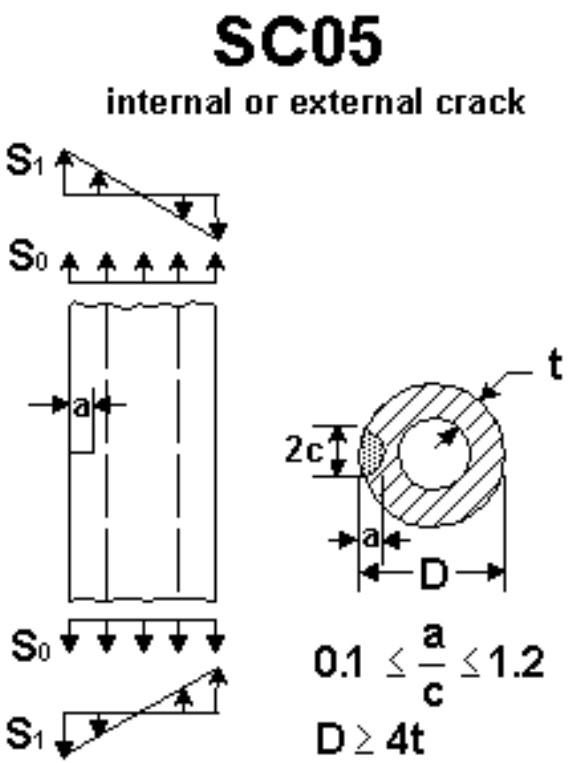
- **Fracture Control (cont)**
- **Fracture Critical components**
  - **Safe-life analysis will be performed with NASGRO program**
  - **Size of flaw will be based on the appropriate NDE techniques or on proof testing**
  - **All fracture critical components will be NDE inspected**
  - **NDE inspections shall be conducted as per standard aerospace quality procedures**

- **Vacuum Case Components**
  - **Inner cylinder**
    - **Inner cylinder classified as low risk**
    - **Material 2219-T852 rolled ring forging (AMS4144)**
    - **NASGRO Model SCO5**
    - **Thickness 0.125 in., diameter 44.398 in**
    - **Crack size a = 0.025 in., a/c =1.0**
    - **Max tensile stress 24842 psi**
    - **Analysis done for STA and flight inner cylinders**
    - **Analysis shows that crack growth is stable**

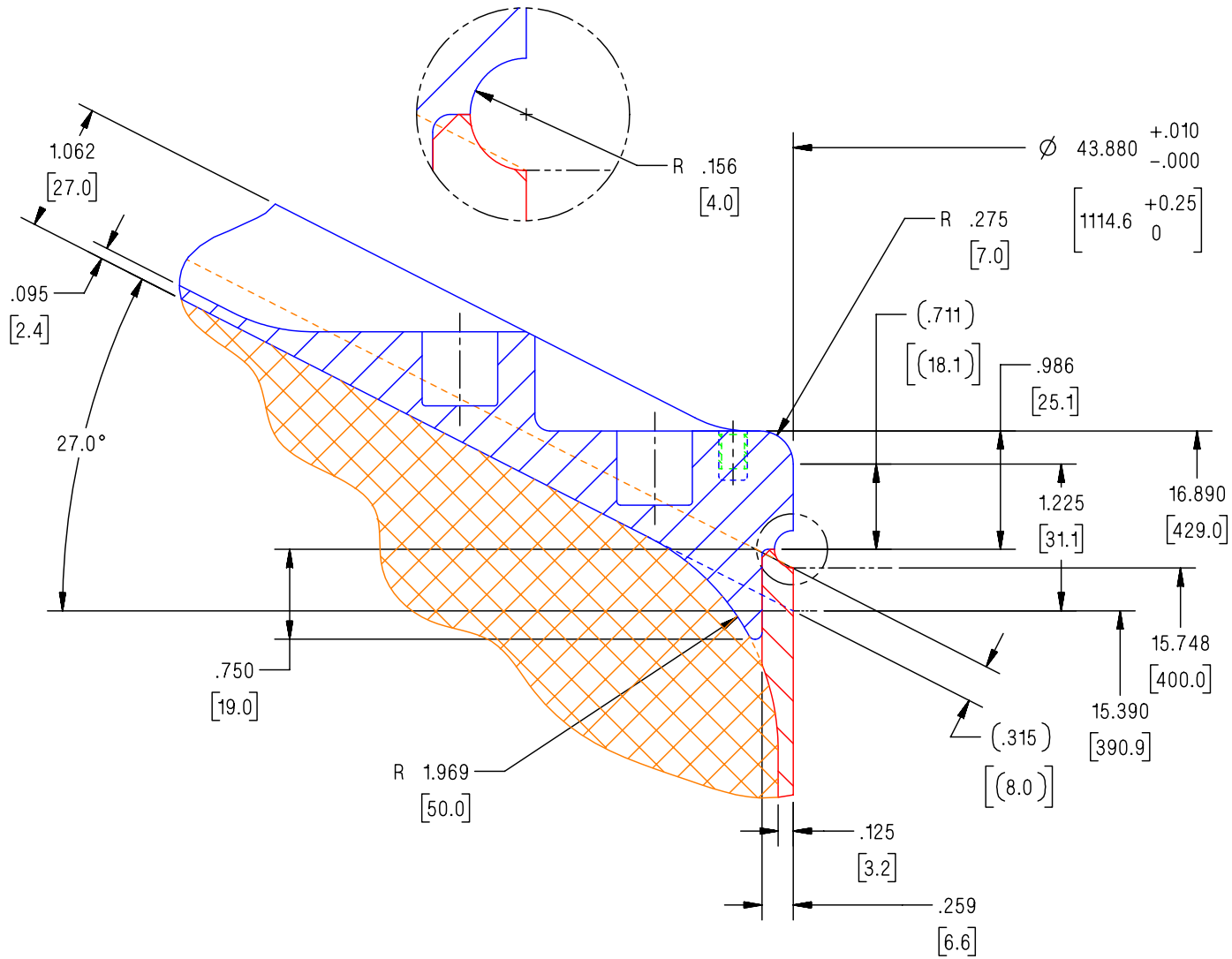




**Crack location for inner cylinder**




- **Inner cylinder weld**
  - **Inner cylinder weld is classified as fracture critical**
  - **Weld properties used from sample tests done at NASA and LMSO**
  - **Dye penetrant and ultrasonic inspection of the weld will be performed**
  - **NASGRO Model SCO5 Thickness 0.259 in., diameter 44.398 in**
  - **Crack size a = 0.075 in., a/c =1.0**
  - **Max tensile stress 22769 psi**
  - **Analysis done for STA and flight inner cylinders**
  - **Analysis shows that crack growth is stable**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1.062
[27.0]
.095
[2.4]
27.0°
Ø 43.880 +.010 -.000
[1114.6 +0.25 0]
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.259
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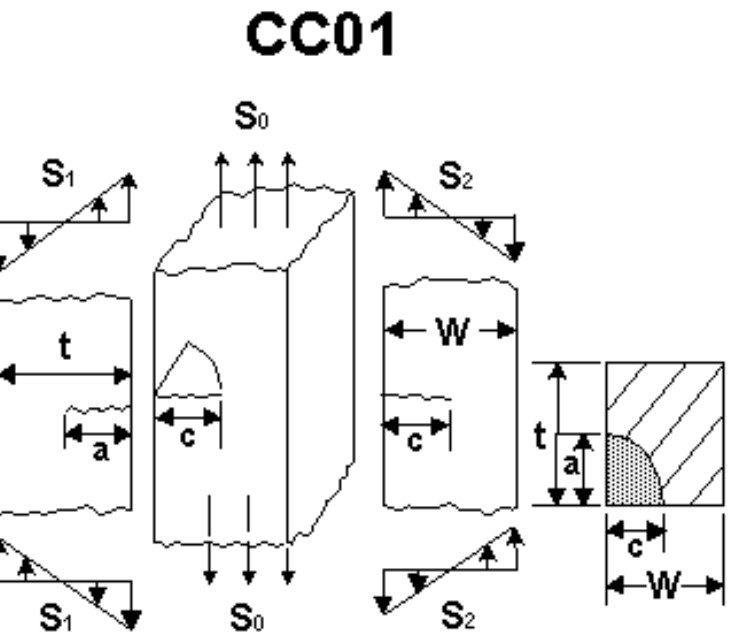
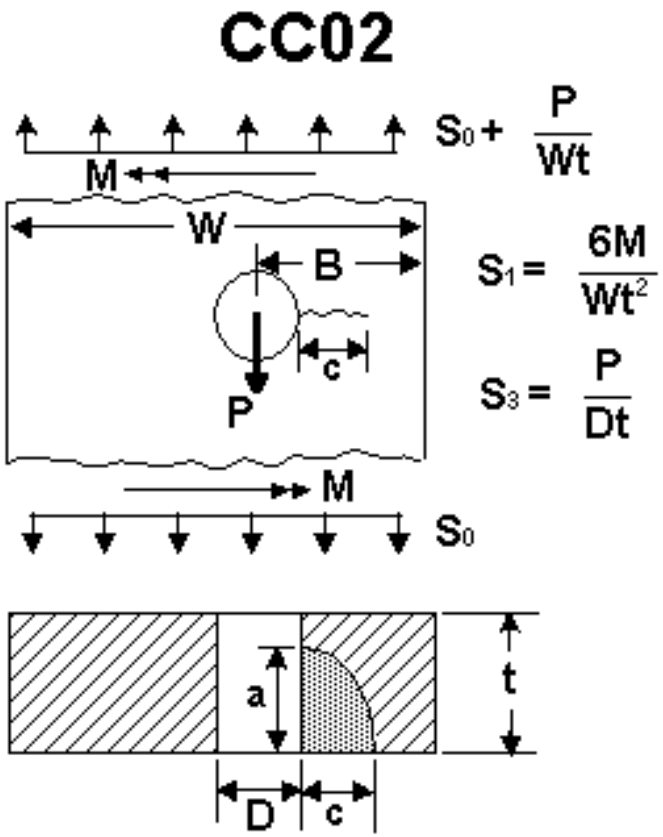
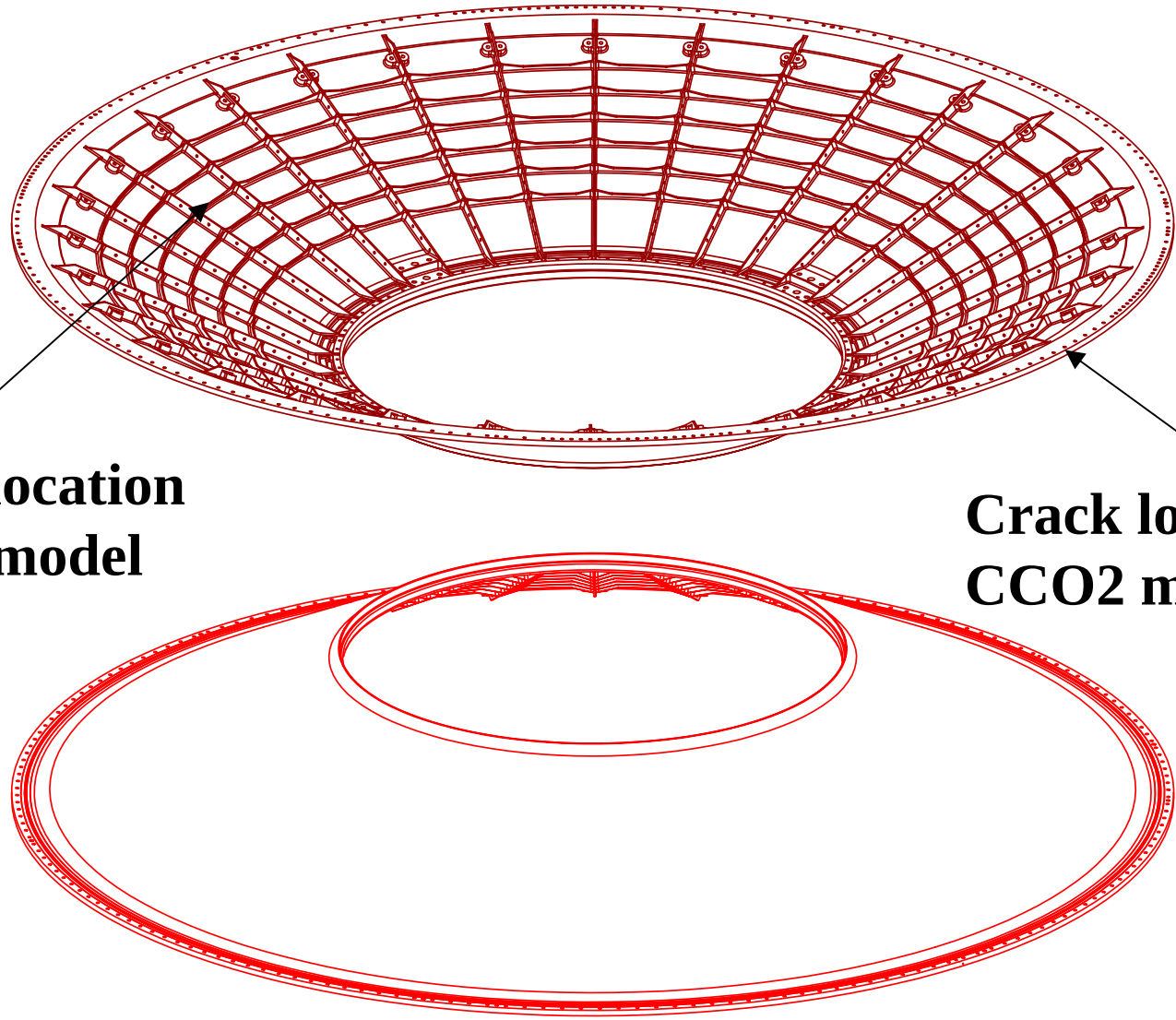



- **Conical Flange**
  - **Conical flange is classified as low risk**
  - **Material 2219-T62 plate**
  - **NASGRO Model CCO1 for conical flange circumferential ribs**
  - **Thickness 0.15 in., Width 0.5 in**
  - **Crack size a = 0.025 in., a/c =1.0**
  - **Max tensile stress 28080 psi**
  - **Analysis done for STA and flight conical flanges**
  - **Analysis shows that crack growth is stable**




- **Conical Flange (cont)**
  - **NASGRO Model CCO2 at conical flange bolt locations**
  - **Thickness 0.50 in., hole diameter 0.272 in**
  - **Crack size a = 0.025 in., a/c =1.0**
  - **Max tensile stress S0=12549 psi,**

    **S3= 11647 psi**
  - **Analysis done for STA and flight conical flanges**
  - **Analysis shows that crack growth is stable**

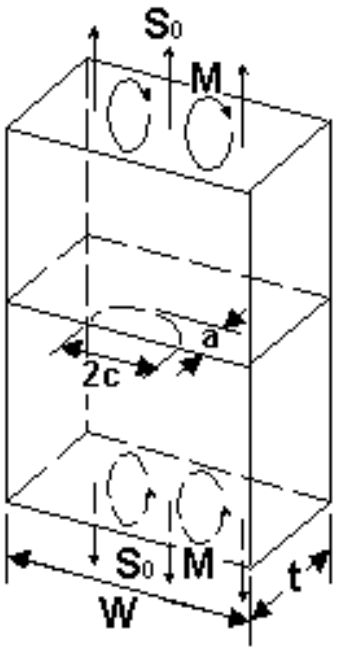


**Crack location**
**CCO1 model**

**Crack location**
**CCO2 model**

- **Support ring**
  - **Support ring is classified as low risk**
  - **Material 7050-T7451 Rolled ring forging**
  - **NASGRO Model SCO1 at lower support ring flange**
  - **Thickness 0.149 in., width 1.625 in**
  - **Crack size a = 0.025 in.,a/c =1.0**
  - **Max tensile stress S1= 21594 psi**
  - **Analysis done for STA and flight conical flanges**
  - **Analysis shows that crack growth is stable**

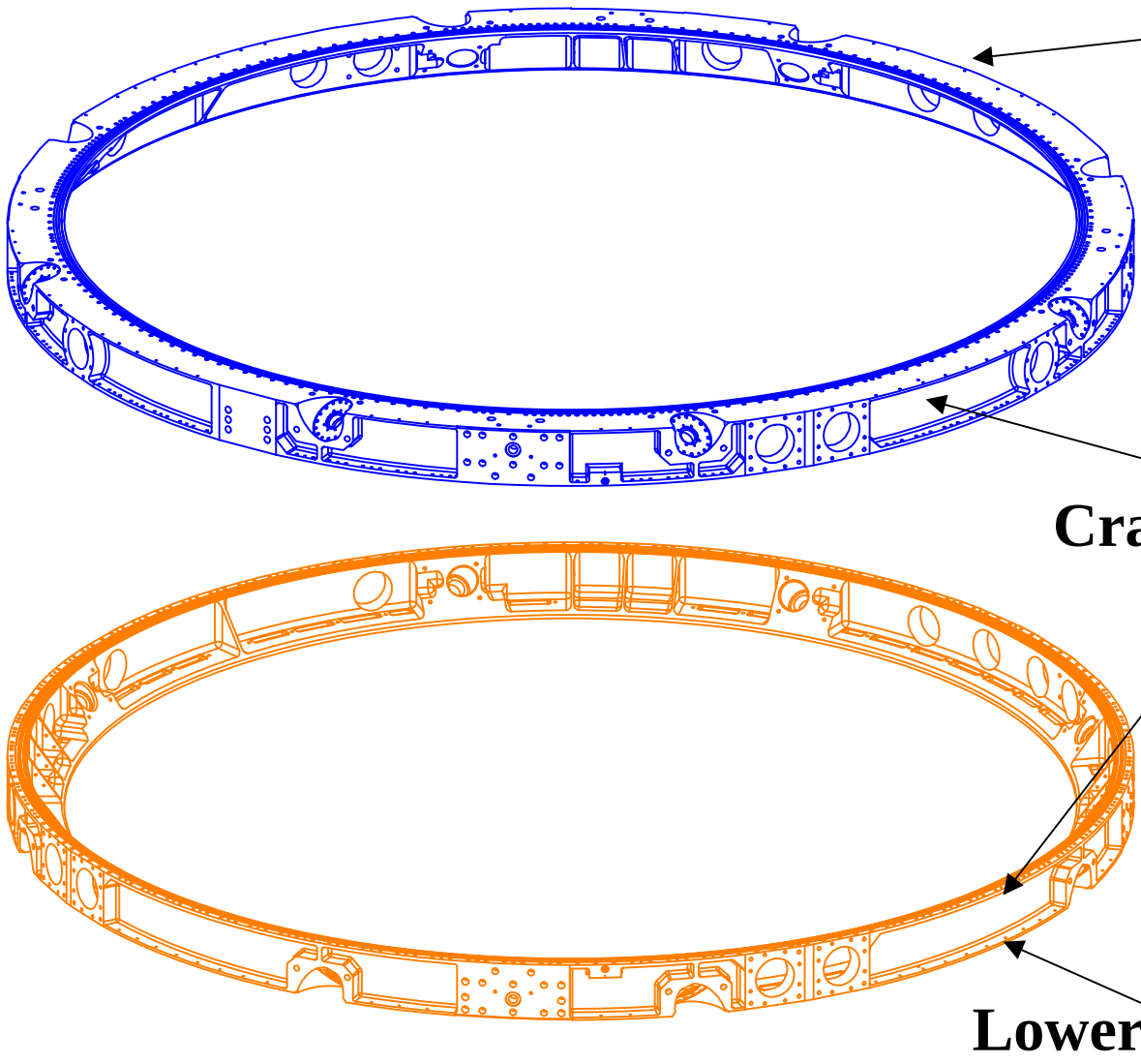
**SC01**




$$S_1 = \frac{6M}{Wt^2}$$

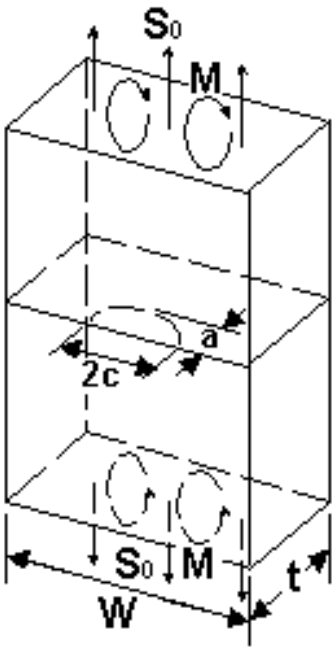
$$0 < \frac{2c}{W} \leq 1$$

$$0.1 \leq \frac{a}{c} \leq 1.2$$


Upper ring
Crack location
Lower ring

- **Support ring (cont)**
  - **NASGRO Model SCO1 at upper support ring flange**
  - **Thickness 0.25 in., width 4.625 in**
  - **Crack size a = 0.025 in., a/c =1.0**
  - **Max tensile stress 23922 psi**
  - **Analysis done for STA and flight conical flanges**
  - **Analysis shows that crack growth is stable**

**SC01**




$$S_1 = \frac{6M}{Wt^2}$$

$$0 < \frac{2c}{W} \le 1$$

$$0.1 \le \frac{a}{c} \le 1.2$$

# AMS-02 Integration Hardware Fracture

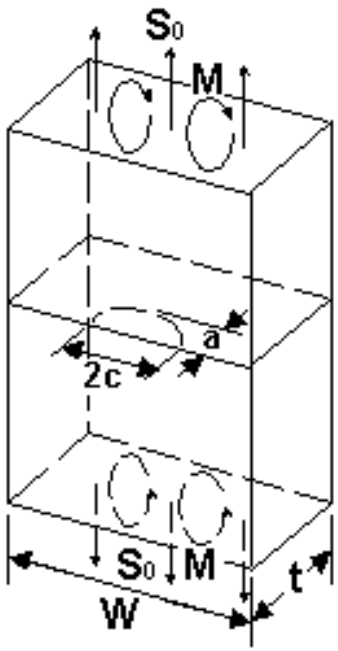
- **Outer cylinder**
  - **Outer Cylinder is classified as low risk**
  - **Material 7050-T7451 Rolled ring forging**
  - **Fracture analysis will be done with low risk crack size**

# AMS-02 Integration Hardware Fracture

- **USS-02 Components**
  - **Friction stir welded tubes are classified as fracture critical**
    - **Upper trunnion bridge**
    - **Lower trunnion bridge**
    - **Lower angle tube**
    - **Weld properties obtained from tests performed by NASA and LMSO**

- **Upper trunnion bridge**
  - **Material 7050-T7451 plate**
  - **Inspection as per NASA/JSC PRC-0014 class A**
  - **NASGRO Model SCO1**
  - **Thickness 0.25 in. width 6.292 in**
  - **Crack size a = 0.10 in., a/c =1.0**
  - **Max. tensile stress 24537 psi**
  - **Analysis shows that crack growth is stable**

**SC01**

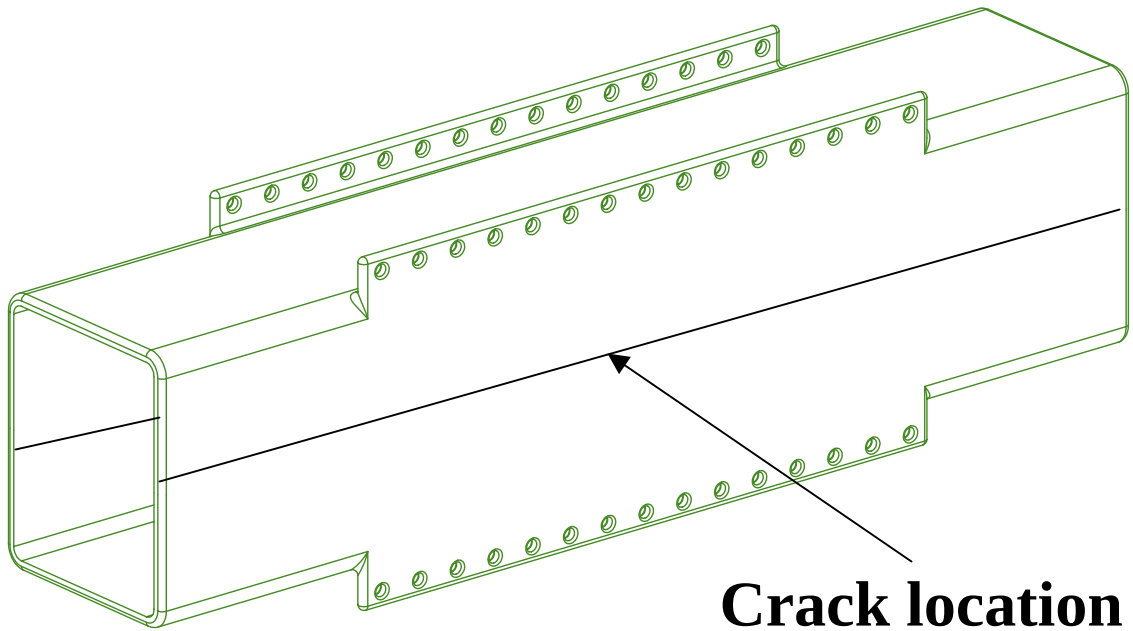



$$S_1 = \frac{6M}{Wt^2}$$

$$0 < \frac{2c}{W} \leq 1$$

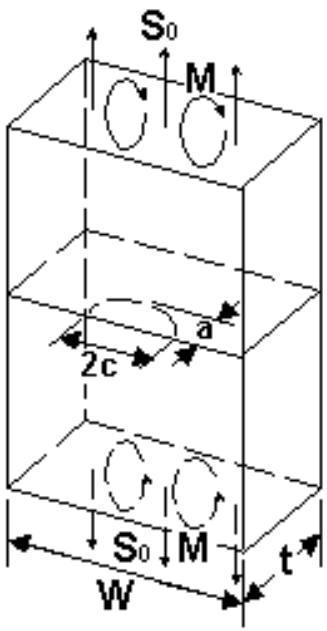
$$0.1 \leq \frac{a}{c} \leq 1.2$$

# Friction stir welded tube



- **Lower trunnion bridge**
  - **Material 7050-T7451 plate**
  - **Inspection as per NASA/JSC PRC-0014 class A**
  - **FLAGRO Model SCO1**
  - **Thickness 0.25 in., Width 4.918 in**
  - **Crack size a = 0.10 in., a/c =1.0**
  - **Max tensile stress 22312 psi**
  - **Analysis shows that crack growth is stable**

**SC01**



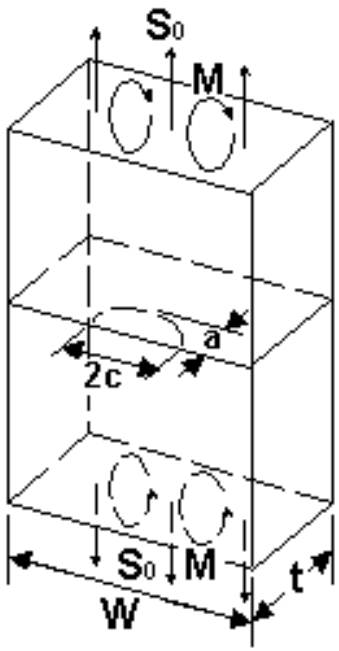

$$S_1 = \frac{6M}{Wt^2}$$

$$0 < \frac{2c}{W} \leq 1$$

$$0.1 \leq \frac{a}{c} \leq 1.2$$

- **Lower angle tube**
  - **Material 7050-T7451 plate**
  - **Inspection as per NASA/JSC PRC-0014 class A**
  - **NASGRO Model SCO1**
  - **Thickness 0.25 in., Width 4.562 in**
  - **Crack size a = 0.10 in., a/c =1.0**
  - **Max tensile stress 18816 psi**
  - **Analysis shows that crack growth is stable**

**SC01**




$$S_1 = \frac{6M}{Wt^2}$$

$$0 < \frac{2c}{W} \leq 1$$

$$0.1 \leq \frac{a}{c} \leq 1.2$$

# AMS-02 Integration Hardware Fracture

- **USS-02 Components (cont)**
- **Fracture analysis for the following items will be done :**
  - **Upper VC joint**
  - **Lower VC joint**
  - **Sill joints**
  - **Diagonal strut**
  - **Sill bracket**
  - **Diagonal sill bracket**
  - **Sill trunnions**
  - **Lower center body joint**
  - **Keel assembly**

# AMS-02 Integration Hardware Fracture

- **The following items on the Payload attach system (PAS) are classified as fracture critical:**
  - **Platform**
  - **Bearing Housing**
  - **Bridge beam**
  - **Capture bar**
  - **Analysis will be done for these items with the standard dye penetrant NDE crack sizes**